EXTENDING/RESTORING THE SERVICE LIFE OF BITUMINOUS PAVEMENTS WITH A HIGH PERFORMANCE, POLYMER MODIFIED CEMENTITIOUS MICRO-SURFACE OVERLAY HIGH PERFORMANCE PAVEMENT MARKINGS

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ABSTRACT

Bituminous pavements suffer the effects of environmental and use exposure from ultraviolet light, water, aggressive chemical spills, and abrasion. The result of such exposure is the deterioration of the pavement from the surface. Oxidation (fading & hardening) of the pavement - causing brittleness, leads to cracking and subsequent crack wall erosion (water stripping of the bituminous binder), which all leads to further water penetration and eventual loss of structural integrity if not addressed in a timely manner. The pavement accordingly suffers reduced color contrast and service life, requiring facility shutdowns for remediation. For these reasons an effective, low cost, long lived method of protection or remediation of new or mildly damaged pavement surfaces is needed.

In 1996 a research and development project was initiated to address these problems. The resultant project culminated in the development of a Polymer/Cement Micro-Surface Overlay product (PCMO) manufactured by Polycon Systems, Inc. of Madison, Mississippi. Polycon Systems, Inc. entered into a cooperative Research and Development agreement with the Army Corp of Engineers, to fully test the PCMO product's ability to preserve bituminous pavements by protecting them from damaging environmental exposure and abrasion. The PCMO product was than installed at the US Army Corps of Engineers Experimental Waterways Station in Vicksburg, and was the subject of laboratory and other in-situ tests. The results of these studies and tests indicate exceptional performance in all categories, leading to the installation of this PCMO pavement protection system on PCC and bituminous pavements.

The polymer/cement micro-surface overlay product has been further refined and formulated to provide a long lasting colored pavement marking product by substituting white cement, white or light aggregates and pigments. This Polymer/Cement based pavement-marking product yields the same durability as the original PCMO product, but also exhibits additional attributes necessary for use as high performance pavement markings, including high retro-reflectivity and high chromaticity retention. Colors currently available include: yellow, white, black, blue (handicap), red, and green.

PCMO overlays and pavement markings can be rapidly installed on mildly damaged, sound substrates allowing for the return of the pavement to service in hours under summertime weather conditions.

Commercial applications have illustrated these products are a cost effective method of pavement restoration, repair and marking, as well as for uses designated as preventive measures before pavements reach the point of degradation.

The FAA has approved the use of the PCMO product on asphalt apron areas through the publishing of Engineering Brief 62.

INTRODUCTION

Bituminous pavements left unprotected are often damaged by spills or localized abrasion. These surface defects, often affecting only the upper layers of pavements are good candidates for micro-surface remediation using a new system developed by PolyCon Systems, Inc., Jackson, MS in the late-90s, using a polymer modified cement composite. This polymer/cement micro-

surface overlay (PCMO) product is installed in thin sections over new or mildly damaged sound pavement to restore the pavements ride, traction and appearance for safe visibility. The PCMO is resistant to attack from aggressive fuels, lubricants, and chemicals and exhibits resistance to abrasion. [1]

Protecting bituminous pavements from early failure from environmental degradation, wear, fuels, lubricants and maintainance chemicals commonly used in operating the equipment the pavement was built to carry, is a desirable and necessary measure to protect the infrastructure investment and maintain use availability.

It is often necessary to perform maintenance and repair to pavements that are otherwise capable of performing under prevailing service conditions due to minor surface damage, effects of ageing, or small area failures. Micro-surfacing to restore and protect these pavements is a viable method of extending their life and serviceability.

To protect bituminous pavements from these effects, a variety of surface coatings have been widely used for decades. The coating system most commonly used for this purpose when fuel resistance is a concern has been a “Coal Tar Emulsion Seal Coat”. Although these products can be effective, this product category is facing mounting pressure due to environmental and health concerns. [2]

An alternative surface sealant product based on polymer/cement technology offering improved wear, chemical resistance, adhesion, friction options and esthetics at a competitive price has been installed and evaluated on various pavements. Because the binder system relies on Portland cement, available in white, and a milky white polymer additive with mineral aggregates, this combination can be manipulated to provide several needed pavement solutions:

- Can be pigmented to any color. For this reason pavement markings with the same performance properties have been formulated to meet pavement-marking needs with long-lived, abrasion, UV and chemical resistant multi-colored markings.
- Can be installed as a patch, to restore profile or fill holes
- Can be imprinted with various surface textures or seeded with exposed aggregates to affect pavement friction values.
- Provides colorfast surfaces that will retain their color and contrast for extended periods of time.
- Installs rapidly and will accept markings after initial set, speeding return-to-service in hours.
- Can be installed on very new HMA pavement after removal of surface oils.
- Offers excellent adhesion on HMA pavements with minimal surface preparation
- Holds up to abrasion and moderate impact.
- Provides excellent resistance to water penetration.

- Provides excellent resistance to aggressive fuels and chemicals commonly found on airfield pavements.

In 1998 after successful field trials on public streets and parking areas, a Cooperative Research and Development Agreement was undertaken with The US Army Waterways Experiment Station, Vicksburg, Mississippi, comparing PCMO surface treatments to coal-tar-sealers.

Results of laboratory and field studies at eight military sites concluded - “Superior in fuel resistance, abrasion, and weathering resistance” leading to acceptance and use on airfield pavements under FAA Engineering Brief 62 [3].

PCMO projects were then undertaken on military and general aviation airfields, in addition to State DOT projects including bridge deck re-surfacing with a heavier, textured version of PCMO containing a seeded surface aggregate.

These experiences lead to further development of equipment to accommodate the mixing and installation of PCMO products. This equipment is reasonably simple and inexpensive and in some instances (Markings) required slight modifications to existing equipment. PCMO’s are installed as a thin layer (1/16-3/8 in.), a squeegee is employed to control the coating thickness and spread the PCMO evenly on the pavement surface. Mixing can be accomplished in a concrete drum mixer, or, a mortar type batch mixer. Small quantities can be successfully mixed using a “Mud” mixer blade powered by an electric drill mixed in pails.

PCMO – THE SYSTEM

PCMO is a highly polymerized concrete product containing water-based emulsion polymers, Portland cement, aggregates, dispersants, defoamer, setting agents, pigments, mineral fillers and water. The ingredients are mixed in conventional mixing equipment to a flow-able consistency and spread on a prepared surface to form a thin protective surface coating. Thickness, texture and color can be modified to fit various pavement needs.

Typical applications are:

- Long-lived protective coatings on HMA & PCC pavements for protection from UV, aggressive chemicals, fuels and lubricants.

- Chemical resistant coating for fueling & de-icing areas.

- Wear resistant coatings for improved pavement performance in areas of heavy wear.

- Pavement surfaces needing improved friction characteristics, including bridge decks, pedestrian walkways, ramps, parking structures, taxiways, aprons and runways.

- Long-lived pavement markings in standard pavement marking colors.

- Fast, affordable method of quickly restoring worn, cracked, rough oxidized or mildly damaged surfaces.

PCMO is supplied as a two-component system consisting of wet & dry ingredients. The manufacturing and supply system ships “kits” of various yields to accommodate individual project requirements. This system also serves to provide a layer of quality control assisting field mixing/installation crews by simplifying mix-ratio issues.

After thorough mixing, the PCMO material is spread by squeegee onto the pavement surface. On pavements requiring high surface friction, aggregates are seeded onto the wet PCMO immediately following the application squeegee. Texture may be applied by tining or texturing the fresh PCMO treated surfaces with tinning fingers or a texturing roller.

Depending on temperature, sunlight, wind and humidity, the thin layer of PCMO sets as water evaporates, whereby the discrete polymer spheres approach each other, eventually fusing into a continuous film (as reported in Lavelle [4]), and the surface hardens allowing for foot or light wheeled traffic. At this time pavement markings can be installed and pavements subjected to light traffic can be returned to service.

Due to its Portland cement content, the PCMO surface coating continues to gain strength, depending on the formulation, for up to 30 days. PCMO surfaces on pavements subject to heavy to severe use must be evaluated for strength gain prior to returning them to service.

PROJECTS OVERVIEW

Typical Airfield Pavement Restoration Project: Tupelo Regional Airport – Tupelo, Mississippi

In August and October of 2001 work was performed on the 4,500 ft. parallel taxiway and three connecting taxiways at the Tupelo Regional Airport to install PCMO on these weathered airfield surfaces. This project also included colored PCMO pavement markings (centerline and hold-short markings).

The existing pavement was last serviced in 1996/97 with a typical mill and fill HMA overlay. The pavement condition was sound, mildly oxidized, pitted and rough. Standard gray PCMO was selected to micro-surface this area. The PCMO installed did not contain any surface aggregates or texture.

The project area of approximately 50,000 square yards of PCMO and 5,000 square feet of Colored PCMO pavement markings was installed by Polycon crewmembers, with large batch mixing needs accomplished with a rented concrete truck mixer and a 400 gal. batch mixer, due to project size.

By all reports, the management of this facility is very satisfied with the appearance and performance of the PCMO pavement surface and plans on utilizing this micro-surface system on future remediation projects at this facility.

In December of 2001, MDOT ran pavement friction tests on the PCMO pavement sections in accordance with ASTM E274-90. The friction values obtained from these tests indicate satisfactory friction levels with no areas failing [5].

Typical Airfield Protection Application: Coshocton County Airport – Coshocton, Ohio

In October of 2003 approximately 166,000 sq. ft. of PCMO in black, with a sanded friction surface was installed over new HMA pavement on the apron area recently constructed at this facility. The HMA surface was 2 to 4 weeks old. PCMO was specified with a 10-year performance guarantee.

Installation was performed by PolyCon personnel using a trailer mounted 2 cubic yard rotating drum mixer hitched to a flat bed truck - creating a paving train with the squeegee and sand spreader following, to complete the lay down operation.

This new apron area was not in service, so adverse weather conditions on some mornings less than 45°F, did not cause operational problems, however cure time was extended, in some cases overnight. The project was completed in one work week, with delays due to cold weather and rain events.

The management of Coshocton County Airport and the specifying engineer are very satisfied with the appearance and performance of their PCMO treated apron and they are planning future PCMO installations at this facility.

Inspection on March 9, 2004 shows the PCMO surface installed last fall to be in the same condition as installed, following a normal mid-Ohio winter.

OPTIONAL SURFACE TREATMENTS – FRICTION

In the fall of 2003, PolyCon Systems, Inc. participated in the 10th Annual NASA Tire/Friction Workshop held at NASA Wallops Flight Facility, Chincoteague, VA.

Two PCMO “Test Sections” were installed in the test area and subjected to the group’s various friction-testing devices for the purpose of establishing friction values and calibration between the various test devices.

EK1 – Standard PCMO

EK2 – PCMO with seeded surface sand applied

The friction testing experience taught us many things. Among the most important, standard PCMO taxiway surfaces should be modified with friction aggregates to improve friction values for maximum safety and performance.

This experience also leads to an effort to optimize friction characteristics, and test specimens were created for this purpose. The PCMO mix was augmented with 3/8” X #8 granite aggregate and several samples were tined to maximize macro-texture. The specimens were than submitted to John J. Henry, Consultant, for friction testing using the Dynamic Friction (DF) Tester for friction testing and the Circular Track (CT) Texture Meter for macro texture measurement, and then correlated to the recently developed NASA Wallops friction data (tables 1 and 2, figure 1).

Based on the high friction values obtained, a major North American airfield requested verification of chemical compatibility with a rubber removal chemical used at their facility, prior to considering use on an upcoming runway remediation project scheduled for August 2004. The test specimens were subjected to overnight soaking in a topical application of potassium acetate, broadcast application of de-icing pellets and vigorous brushing with a steel broom. No apparent wear or degradation was detected

Some additional points of interest are:

- Friction values of 90+ were achieved with a tined surface that allows for control of surface water.
- The high friction is derived from the macro-surface-texture.
- The aggregates, as installed, are covered with a coating of polymer/cement matrix. As wear exposes the coarse aggregate surfaces, this value should hold or rise as the coarse aggregate's micro-surface-texture makes more of a contribution.

Table 1.
Friction Tests – High Friction PolyCon Samples (John J. Henry, Consultant).

	DFT20	MPD	MTD[a]	Sp[b]	F60[c]	SN64B[d]	GT 65[e]	SFT79 65[f]	SFT79 90[g]
ASTM Standard	E1911	E2157 and E1845	E965	E1960		E274	E1844	Force	
PANEL									
I	0.541	1.54	1.53	161.9	0.39	36.4	0.463	0.657	0.642
T	0.546	1.48	1.47	155.5	0.39	36.4	0.468	0.665	0.649
#2	0.626	1.17	1.18	122.1	0.411	38.3	0.546	0.785	0.761
A	0.725	1.85	1.82	195.3	0.513	49.6	0.614	0.916	0.899

[a]MTD = 0.947 MPD + 0.069
[b]Sp = 113.6 MTD - 11.6
[c]F60 = 0.081 + 0.732 DFT20/[exp(40/Sp)]
[d]SN64B = (F60 - 0.0446)/(0.9255 exp[4/Sp]). NOTE: SN64B values should be higher than 25. (This is for the E274 trailer with a smooth treaded tire.)
[e]GT 65 = 0.804 DFT20 exp(10/Sp)
[f]SFT79 65 = [1.348 DFT20/exp(40/Sp) - 0.088] exp(50.25/Sp)
[g]SFT79 90 = [1.348 DFT20/exp(40/Sp) - 0.088] exp(46.5/Sp)

Table 2.
Wallops 2003 Data for Site EK2.

	DFT20	MPD	MTD	Sp	F60	SN64B	GT
Predicted	0.773	0.47	0.51	46.8	0.6	55.1	0.77

	E274 Trailers (SN64B)			Griptesters (GT)	
	OH	VA	FL	DND	USAF
Measured	40.1	45.4	46.9	0.71	0.54

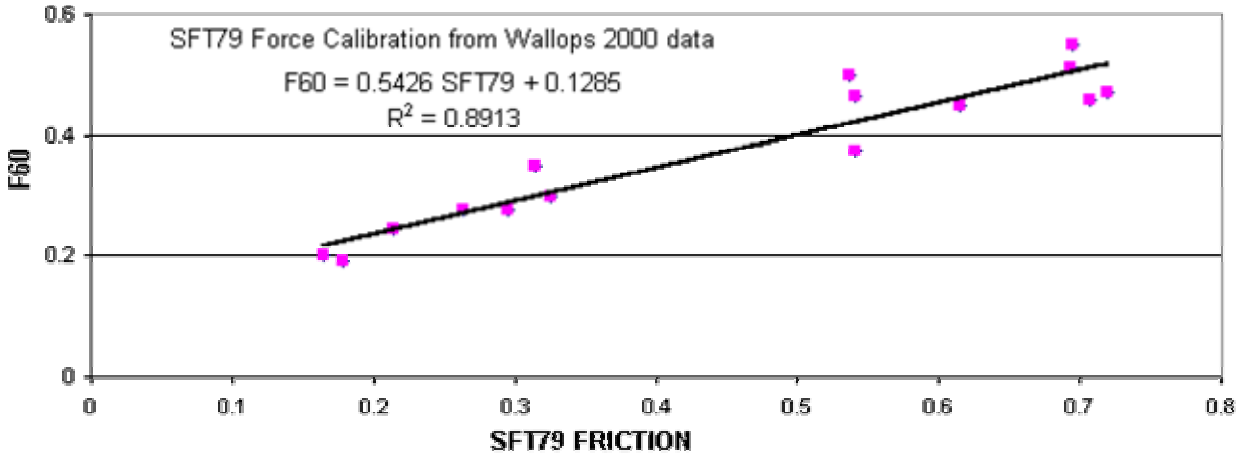

Figure 1. SFT79 Force Calibration from Wallops 2000 Data.

The next step is to install this high friction product on an airfield pavement and evaluate its performance in service. This "high friction" product is similar to a PolyCon product used on bridge deck re-surfacing in Ohio, Mississippi, New York and Tennessee that has been extensively studied by various highway departments in service since 1998, with good to excellent results.

Table 3.
Tennessee Department of Transportation (TDOT) PolyCon BD2000 Bridge Deck Re-Surfacing.
PCMO Micro-Surface with Exposed Aggregate.
After 9 Months Service at 40,000 ADT (TDOT, August 7, 2002 [6])

Test	Ref. Standard	Result
Spalling or Loss of Surface Material		None
Chloride Ion Penetration	AASHTO T-259,T260 (90 day ponding)	None
Compressive Strength, 28 day	ASTM C-109	2080 psi
Bond Strength, Slant Shear 3"X 6" cyl.	ASTM C-882, 7day	493 psi
Skid Numbers[a]		Acceptable

[a]Due to equipment loss unable to correlate. 3mo. = 72.1

PAVEMENT MARKINGS

Colored PCMO pavement markings have been installed with and without reflection beads on several airfields, parking areas and highway pavements over the past six years. Performance as measured by wear is excellent. Reflectivity and durability is currently under study by the Ontario Highway authorities on a Canadian test pavement area located on RT401 East between Toronto and Montreal. This test area was considered ideal due to the severe environmental exposure, high traffic count and use of plows and power brooms on this major highway pavement. Early results

on retro-reflectivity are good. Long-term durability, plow survivability and retro-reflectivity are still under study, with no problems to date.

CONCLUSIONS

Thin Polymer/Cement micro-surface overlay (PCMO) treatments have shown promise in restoring and protecting the surface of bituminous concrete pavements from ultraviolet degradation, aggressive chemicals, fuels and lubricants. In addition, wear protection and long lasting colorfast surfaces are possible with this method, assisting pavement owners/managers in providing high visibility, long service life and good appearance.

PCMO products are environmentally friendly requiring nothing beyond those measures employed with Portland cement concrete for safe handling and disposal of excess materials.

Friction improvement options to meet a wide range of requirements using this micro-surfacing system are rapidly developing and offer promise for airfield and highway pavements suffering from low friction values.

The fast installation and return to service feature of this system offers the benefit of a remediation option for those pavements that cannot be out of service for extended periods of time.

Pavement markings with good color retention and wear resistance with the same performance properties are available.

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